A Space-based System for Investigating the Response of Stimulated Ionosphere

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Abstract
The **OSIRIS-3U** (Orbital System for Investigating the Response of the Ionosphere to Stimulation and space weather) mission will investigate space weather phenomena by providing *in situ* and remote sensing measurements of the stimulated (heated) ionosphere. The HF heater at Arecibo Observatory will stimulate the ionosphere to mimic natural ionospheric irregularities at defined locations and times. OSIRIS-3U's primary objective is to characterize the spatial extent and internal structure of the heated region. The OSIRIS-3U mission has been selected by NASA's CubeSat Launch Initiative and is scheduled to launch in mid 2017.

We present innovate solutions to the unique challenges of *in situ* measurements inherent to the CubeSat platform. Size, mass, and power constraints coupled with non-linear interactions among measurement devices, spacecraft, and the ionosphere require **dual-purpose materials** that maximize the utility of spacecraft surfaces and other resources while enabling accurate data collection.

Science Questions

- Where does the plasma go when large ionospheric bite outs are produced in the *F*-region by high-power radio waves?
- What are the fine-scale structures within the bite outs?
- What effects are observed at the geomagnetic conjugate points

Ground Station
State College, PA

Artificially Stimulated Region
Beamwidth: 6.5–10.1°
Satellite Transit Length: ~70 km
Satellite Transit Time: ~10 s

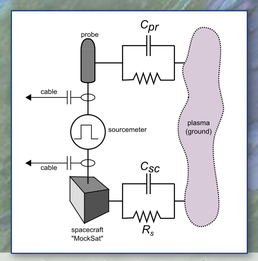
Orbital Characteristics (nominal)
Altitude: 400 km, circular
Inclination: 51.6°
Lifetime: >6 months

Scientific Instrumentation

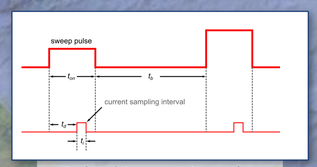
Pulsed Langmuir Probe
- Local electron density and temperature measurements
- Pulsed technique mitigates contamination effects
- Designed and provided by Penn State

Compact Total Electron Content Sensor (CTECS)
- GPS radio occultation sensor
- Provides slant TEC and scintillation data
- Designed and tested by The Aerospace Corporation

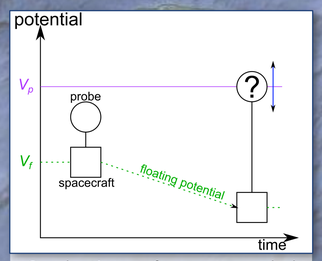
Coherent Electromagnetic Radio TOmography (CERTO)
- 2D tomographic reconstruction of the electron density (between satellite path and receiver)
- Designed and provided by the Naval Research Laboratory



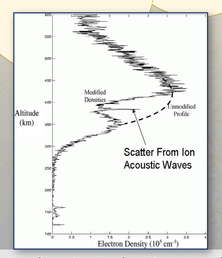
Contamination can be modeled as an RC element between probe and plasma [3]



Pulsed Langmuir probe measurements mitigate contamination effects [3]



Conductive surfaces are needed for positive ion collection to avoid spacecraft charging



Electron density reduction produced by 3.175 MHz operating at 80-MW effective radiated power [1]

Image of Earth from Google

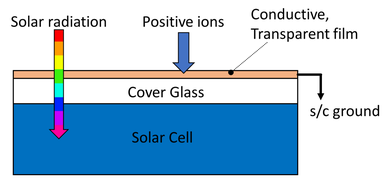
References
[1] Bernhard, P., C.A. Selcher, and F.T. Djuth, "Three-Dimensional, Tomographic Imaging of an Artificial Ionospheric Hole", 2001 NRL Review, p. 79, 2001.
[2] McTernan, J. K., T. R. Brubaker, and S. G. Bilén, "Indium Tin Oxide Coverings on Solar Panels for Plasma–Spacecraft Connection", in IEEE PVCS Conference, June, 2013.
[3] McTernan, J. K., T. R. Brubaker, and S. G. Bilén, "The Pulsed Langmuir Probe Technique to Mitigate Contamination Effects on Small Spacecraft", in 13th Spacecraft Charging and Technology Conference, June 2014, Pasadena, CA, 2014.

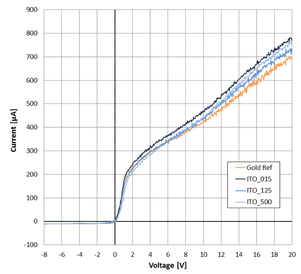
Ground-based Heater
Location: Arecibo, Puerto Rico
Power: ~200 MW EIRP
Frequency: 5.125 and 8.175 MHz

Dual-Purpose Materials

Indium Tin Oxide (ITO)-coated coverglass for solar cells

- Transparent to solar energy (~92%)
- Conductive for passive ion collection





Current–voltage characteristics of ITO-coated glass (various sheet resistance) compared to gold show effectiveness of dual-purpose material as a passive ion collector [2]

Ground-based experiments in a LEO-like environment demonstrate feasibility on small-scale spacecraft